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THE ENGINEERS BLUE BOOK

COST DATA ON ENGINEERING

Making Surveys, Drafting, Etc.

JOHN WILKES
CIVIL ENGINEER

SECOND EDITION.

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NASHVILLE, TENN.,
1915

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FIELD WORK

Chaining

	Ft. Per Hr.
Minimum	1280
Average	2660
Maximum	4580
Another Job	
Minimum	4950
Maximum	5280

Careful Chaining (Plumb with Transit Rods) (Nob P.52)

Average for $7\frac{2}{3}$ hrs	1900
Maximum (Av. of 2 hrs. work)	2505

Compas Line 10,000A Survey

	Ft. Per Hr.
Average work done in Jan'y.	1650
Maximum in open woods	4000
Another Job	
Open fields and Woods	2286
All Woods	1550

Transit Line Open Fields

Ref. No.	No. Helpers	Hrs. Ave.	Ft. Per Hr.
1	2		1000
2	2		915
3	2		722
4	2		800
5	2		1077
6	2		1038
7	2		1400
8	2		650
9	2		720
10	2		601
11	2		600
12	2	6	657
13	2	$6\frac{1}{3}$	1430
14	2	$6\frac{1}{3}$	1327
		Average	926

Trans'mn. 2 Rodmen

Per Hr. 0.60 / 0.40 / $1.00

Cost per Mile

$\frac{5280}{926}$ 100 = $5.70

Field Work

Transit Line In Woods Clearing Required

Ref. No.	No. Helpers	Hrs. Ave.	Ft. Per Hr.
1	2		462
2	2		502
3	2		270
4	2		525
5	4		630
6	4	4	765
7	–	4	700
8	–	3	733
9	–	$6\frac{1}{2}$	656
10	3	5	720
11	3	$1\frac{3}{4}$	915
12	3	2	1100
13	3	$\frac{5}{6}$	1080
14	3 (No. 10-13)	9.58	866
15	$3\frac{1}{2}$	25	676
		Average	587

Cost per Mile
5280 / 587 1.20 = $10.80
1 Instrumen 0.60
3 Rodmen 0.60
$1.20 Per Hour

Transit Line General Average (Open Fields + woods)

	Ft. Per. Hr.
Average of 26 "	703
Av. 2 Helpers	440 Ft per Hour
" 3 "	866 " " "
" 4 "	697 " " "

Transit Line

	Ft. Per. Hr.
Average for 1 helper (10 Jobs)	659
" " 2 " (10 Jobs)	832

Field Work

Levelling

Ref. No.		Ft. Per Hr.
1	Check B.M. to B.M.	3150
2	" " " "	2740
3	Woods Hilly 100' Stas.	1134
4	Hubs Only	1579
5	Woods 100' Stas.	1240
6	Meadows 100' "	2060
7	Open 100' "	1800
8	Mountain 100' "	700
9	100' Stations	1650
10	" "	1500
11	Town Streets	2055
12	100' Stations	2500
13	" "	1200
14	" "	3000
	Average	1767

Per Hour
Leveler 0.60
Rodman 0.20
$0.80

Cost per Mile
5280/1767 080=$4.240

Levelling 100' Stations ℄ and 20' Right & Left St. Work.

Ref. No.		Ft. Per Hr.
1		1128
2		475
	Average	802

Cost per Mile

5280/802 080 = $5.25

Field Work

Cross Sectioning (Roads)

Ref. No.	Points Per Section	Dist. Bet. Sects.	Feet of Line Per Hr.	
1	–	–	585	
2	7	50	700	
3	–	–	110*	
4	7	–	462	
5	7	100	500	
6	3	100	1650	Town St.
7	3	50	510	
	Average		645	

*Assistant.

Cost per Mile

	Per Day
Instrumentman	$8.00
Rodman	1.50
	$9.50

645 × 9 = 5805' per day = 1.1 Miles

$\frac{9.50}{1.1}$ = $8.64 per mile

Cross Sectioning (Railroad)

Days	Hrs.	Ft.	Ft. per Hr.
½	4(?)	2000	500
½	4	1600	400
1	8	4000	500
1	8	2400	300
½	4	900	225
½	4	2600	650
1	8	1700	212
1½	4	2600	650
½	6	3000	500
½	4	2300	575
½	4	2000	500
	58	25100	433 = Average.

Cost per mile $\frac{5280}{433}$ 1.00 = $12.20 per hr. Engr. 0.75 Rodman 0.25 $1.00

Field Work
Stadia

Shots Per Hour — Lost Time Not Counted Out

Ref. No.	Hours Averaged	No. Rodmen	Shots per Hour
1	5	-	44
2	60	-	38
3	1	2 and Recorder	76
4	7	-	40
5	80	-	23
6	5	-	37
7	2	-	35
8	-	-	31
9	4	-	25
10	3	-	22
11	-	-	20
12	-	-	24
13	2/3	-	91
14	-	-	18*
15	7	-	18*
16	6	-	7*
17	5 1/3	1	25
18	1 2/3	2	50
19	1 1/2	1	43
20	1 1/4	1	50
21	3/4	1	48
22	6 1/2	1	30
23	6 1/4	-	33
24	1	-	52
25	1 1/2	-	60
26	2/3	-	72
27	8	-	50
28	3	2	38
29	3	2	39
	Average		39

Transitman 75¢ per hour
Rodman 20¢ " "
95¢ " "

Cost per 100 Shots
$\frac{0.95}{39} \times 100 = \$2.42$

* Assistant

Field Work
Stadia

Shots Per Day

Ref. No.	No. Rodmen	Hours in Days Work	Shots Per Day
1	–	–	155
2	–	–	143
3	–	–	90 *
4	–	–	127 *
5	–	–	126
6	–	–	158
7	–	6	159
8	–	–	119 *
9	–	5	99 *
10	–	–	223 *
11	–	–	206 *
12	–	7	120
13	–	–	210
14	–	(Av. 5 days)	123
15	–	–	206
16	1	–	197
17	1	–	403
18	2 and Recorder		358
19	2 " "		523
	Average		197

*Assistants

Cost per 100 Shots

	Per Day
Transitman	$6.00
2 Rodmen	3.00
	9.00

$\frac{100}{197}$ $9.00 = $4.55

FIELD WORK

Stadia Survey of a road. Turning Points only

Ft. per Hour 4300

or 7.5 Miles in 9 hr. Day.

Estimate of Cost per Mile

Instrumentman $4.00 per day

Rodman 1.00 " "

5.00 " "

$\frac{5.00}{7.5}$ = 66 cents per mile.

Usual cost of R.R. Surveys (preliminary) $15.00 to 25 per Mile

Stadia Survey of "Mill Pond" above dam

Tracing Contour of water's edge

Average 970' per hour.

Instrumentman $5.00 per day

4 Axemen + Rodmen

at $1.25 per day $5.00 " "

Total $10.00 " "

9 hrs. Per Day

8700' = 1.65 miles per day

Cost $\frac{10.00}{1.65}$ = $6.05 per Mile

Stadia For Distance

Level bubble on telescope of Transit for Levels. Vertical angles not used, all sights perfectly level. Work done in Virginia Dec. 1910.

Field Work

Grade Stakes

Stakes set in line, driven to exact grade and tack set in each stake

	Hours per 100 feet. A	B	C	D	Average
Measuring	0.248	0.205	0.125	0.155	0.183
Off Stations					
Driving to Grade	0.144	0.181	0.166	0.197	0.72
Setting Tacks	0.046	0.046	0.050	0.021	0.041
Lost Time	0.640	–	–	0.049	0.172
Total	1.280	0.432	0.341	0.412	0.568

Average Cost at $1.00 per hour 57 cents per 100 ft.

Another Job Total Time 0.28 hr. per 100 feet.

Survey of Towns

	A	B	C	D	E
Days engineer	14	19	12	8	7
" helpers	17	16½	12	12	16½
" board	16	24	12	8	9
Amt. Engineer	$140	190	120	80	56
" Helper	25	33	36	18	21
" Board	32	48	24	16	22*
Total amount	$197	$271	$180	$114	99
Miles of Street	–	2¼	4	5¾	6¾
Cost per mile	–	$12.75	45.00	19.80	14.50

* Includes $4 expenses

FIELD WORK

Topographic Survey of Lot by division into 100' Squares and levels at corners

Jobs

	A	B	C	D	E	Average
Acres in Lots	7.50	0.52	2.76	2.50	0.69	

Hours per acre

Dividing into squares	0.515	1.45	1.45	0.97	—	1.111
Levels	0.244	0.97	0.55	0.40	0.94	0.622
Total	0.819	2.42	2.00	1.37	0.94	1.733

Cost at $1.00 per hour $1.73 per Acre.

Survey of Towns For Sewers Etc.

First Town Population 8475

Total days board at hotel	16
Days worked	14
Helpers Time, Days (to 5 men)	17
Rate for Helpers per day	$1.50

Second Town Pop. 4679

Days board at Hotel	24
" worked	19
" " by helper	16½

In 9½ Days surveyed 94760 Ft.
or 10000' per Day. = 1.89 miles per day.

Estimated Cost Per Mile

	Per Day
Engineer	$10.00
2 Helpers @ $1.50	3.00
Board Engineer	2.00
Total	$15.00

$15.00 ÷ 1.89 = $7.95 a mile.

FIELD WORK

Laying off Lots

Ref. No.	No. Lots	Hours	Hours per Lot.
1	12	4	0.33
2	14	7.70	0.55
3	11	6.50	0.60
4	8	6	0.75
5	14	7	0.70
6	9	3.60	0.40
7	39	12.50	0.32
	107	Average	0.44

Cost at $1.00 per hour 44 cts. per Lot.

Laying of Lots Curved Front

Ref. No.	No. Lots	Hours	Hours per Lot
1	11	12	1.09
2	6	3	0.50
3	4	9	2.25
	21	24	1.14

Cost at $1.00 per hour $1.14 per Lot.

Transit Line Traverse

Hours per 100' of Perimeter

	Author Prof. G. W. Pickles.	
Measure angles	0.050	0.025
Chaining	0.022	0.041
Total	0.072	0.066

Survey of Towns

Job E (7 miles)

Population 1000.

	Total	per mile.
Transit Line	$75.00	$10.50
Levels	20.00	3.00
Plusses to show each owner's frontage	10.00	1.50
Total	$105.00*	$15.00

*Includes $6.00 Railroad Fare.

FIELD WORK

Stadia Surveys

Ref. No.	Acres	Days	Acres per day
1	32	1	32
2	207	10	21
3	38	3½	11
4	28	4	7
5	120	5	24
6	50	1½	33
7	150	5½	27
8	86	9½	9
9	15	1	15
10	100	9	11
	826	50	16.5

Cost at $15.00 per day
90 cts. per Acre.

Laying off Driveways

Ref. No.	(Short radius curves)
1	1000' per day including lost time
2	1500' " " deducting " "
3	1554' in 1½ days
4	1554' in 8½ hours net = 188' per hr.

Railroad Surveys

	Per day	Per Week	Per Mo.
Preliminary	2.33	*14	—
Location	0.92	5.50	—
"	0.50	3.00	—
"	2.05	12.30	—
"	—	—	5.05 including lost time

* For 9 weeks.

FIELD WORK

Railroad Curves

(Running Curves only)

	Net Time Ft. Per Hour
A	605
B	720
Average	660

Estimate of Cost	Per Hour
Transitman	0.75
2 Chainmen	0.50
1 Stakeman	0.25
2 Rodmen	0.50
	$2.00

Cost per Mile

$\frac{5280}{660}$ $2.00 = $16.00

"Intersection" made "Equality" found and angle read in 24 minutes, (average of 6) Cost @ $1 per hr. = 40 cts.

Sidewalks, Rate of Laying

Including lost time

Lin. ft	Days *	lin. ft. per day
3800	80	47½
6765	113	60
	Average	54

* Including Sundays.

OFFICE WORK

Drafting (Tracing)

Ref. No.	Scale 1" =	Hours per sq. ft.
1	1'	3.50
2	1"	4.08
3	1'	2.67
4	1"	1.25
5	100'	1.92
6	-	1.50
7	-	1.80
8	50'	5.10
9	100'	2.53
10	100'	0.95
11	300'	3.75
12	40'	0.72
13	4'	1.78
14	8'	0.50
15	-	0.79
16	-	1.04
17	-	1.17
18	-	1.63
19	-	1.14
20	-	1.58
21	200'	2.50
22	100'	0.70
23	100'	1.14
	Average	1.91

At 50¢ per Hr. Av. = $0.095 per Sq. ft.

		Hrs. per sq ft.	Hrs. per Acre
Average for	40'=1"	0.72	0.136
" "	100'=1"	1.45	0.043
" "	200'=1"	2.50	0.019
" "	300'=1"	3.75	0.013

OFFICE WORK
Latitudes and Departures

Courses Calculated

Ref. No.		Per Hour
1	To Minutes	10 *
2	" "	13 *
3	" "	20
4	" "	18
5	" "	30
6	" "	24
7	" "	18 (logarithms)
8	" "	21.6
	Average	19

At 60¢ per hr. Average $3.15 per 100 courses

* Assistant

Latitude and Departures to ¼ degrees

Ref. No.	Hours Averaged	Courses per Hour
1	⅓	69
2	2	38
3	4	35
4	⅓	81
5	1½	62
6	3	69
7	1¼	73.6
8	4	59.5
	Average 3 and 8	47

At 60¢ per hr. Average $1.25 per 100 courses

Calculate Area of Cross Sections

	A.	B.	C.	D.	Aver.
1. Plotting in pencil from field notes	4.40	5.00	8.85		
2. Inking in and putting Grade sec. on	11.00	8.00	—	10.50	13.23
3. Dimensioning sections	5.16	—	—		
4. Calculating Areas	8.05	10.00	5.40	11.85	8.82
5. Cubic yds. from end areas	0.88	1.67	—	—	1.28
Total	29.49	24.67	14.25	22.35	23.33
Checking areas with Planimeter	29.60	—	—	—	—
Grand Total	59.09	Hours per 100 sections			

Calculate Area of Cross Sections of Roads

Ref. No.		Sections per hr.
1		11
2		12
3		9
4	Aver. for 3¼ hours	26
5		6.5
6		14.4
7		12
8		5.5
	Average	12

1/12 hr. per Sect. @ 60¢ hr. = 5¢ Sect.
or $5.00 per 100 Sections

OFFICE WORK

Calculate Area of Cross Sections
Railroad Cut.

	Hours per section
Multiplication	0.111
Add of Areas	0.071
	0.182

Equal to 5.5 Sections per Hr. complete.

Sections Complete

Hrs.	Sections	Sect. Per. Hr.
5.5	14	2.55
1.0	8	8.00
4.0	17	4.25
1.5	5	3.33
1.0	5	5.00*
0.66	5	7.50*
13.66	54	3.96*

*Assistant

At 60¢ per hour
Cost 15¢ per Section
or $15.00 per 100 sections.

OFFICE WORK

Ref. No.	Hrs.	Sections	Sects. per Hr.
1	2.5	50	2.00*
2	3.5	10	2.86*
3	1.0	9	9.00
4	2.25	11.5	5.10
5	2.8	14.5	5.18
6	4.3	17	4.00
7	9.0	27	3.00*
	41.8	107	2.50

*Assistant

Above is Measurement of Cross Section Areas with Planimeter.

Measure Cross Section Areas by Paper Strip Method

Ref. No.	Hours	Sections	Ordinates per sec.	Sections per Hr.
1	0.14	10	15	72 (?)
2	-	-	36	6
3	-	-	17	16
4	-	-	14	14
5	-	-	20	26
6	-	-	-	19
		Average		26

At 50¢ per Hour	Per 100 sections.
Areas by Planimeter	$ 20.00
" " Paper Strip	1.95

OFFICE WORK

Calculate Area of Farm by Latitudes and Departures

Ref. No.	Acres	Sides	Calc. Lats	Calc. Dep.	Total Area
			Minutes		
1	65	20	30	45	75
2	45	14	20	30	50
	110	34	50	75	125

At 60¢ hour
Cost $1.25 for 110 Acres
or $1.15 per 100 ft.

Plotting Traverse

Ref. No.	Courses per Hour
1	18
2	28
3	36
4	48
5	54
6	44
7	43.2
Average	38.8

At 50¢ per hr.
cost $1.30 per 100 courses.

OFFICE WORK

Plotting Lots

Ref. No.	Lots	Minutes	Lots Per Hr.
1	114	360	19
2	21	90	14
3	14	28	30
4	14	23	36.5
5	13	25	31.2
6	11	48	13.8
7	10	36	16.7
	210	639	19.7

At 50¢ hr.
Cost per 100 Lots = $2.55

Lots, Cost of Laying off

Field Work 0.44 hr. @ $1 = $0.440
Office " 0.0508 " @ 0.50 = 0.025
Or 46.5 cents per lot $0.465

Plotting Ratio

Ratio of Time Required in Office to Plot to Time Required in Field for Survey

Ref. No.	Hrs. wk. in Field	Hr. wk. in office	Ratio
1	24	0.66	0.028
2	20	1.25	0.062
3	10	0.20	0.020
4	5	0.25	0.050
5	1.75	0.20	0.114
6	-	-	1.000
7	-	-	0.430
8	2.92	1.33	0.457
9	9.25	0.75	0.081
10	3.50	1.58	0.452
11	-	-	0.473
		Average	0.288

OFFICE WORK

Reduction Stadia Notes by Diagram

Ref. No.	Shots per Hour
1	190
2	125
3	150
4	200
Average	166

Cost at 50¢ per hour
$0.43 per 100 shots

Plotting Stadia Shots

Ref. No.	Shots	Hrs.	Shots per Hr.
1	132	3	44
2	60	1¼	48
3	112	2½	45
4	78	1	78
5	234	4½	52
6	-	-	56
7	68	1	68
8	52	1	52
9	120	2	60
10	705	8½	84
	1561	24¾	56.4

Omitting No. 6.

Cost at 50¢ hr
$0.89 per 100 Shots

Plotting Stadia Shots per Day

Ref. No.	Shots per Day
1	462
2	705
3	218
4	300
5	249
Average	387

At $4 per day Cost $1.05 per 100 Shots

MISCELLANEOUS ERROR

Closing Error of Traverse

Ref. No.	Ft. Per Mile
1	1.98
2	2.18
3	1.04
4	7.95
5	5.60
6	3.50
7	2.16
8	1.19
9	0.74
10	3.08
11	1.44
12	1.80
13	0.27
14	2.99
15	3.70
16	0.53
17	2.18
18	0.36
Average	2.30

Closing Error Angular value of K in the formula $e = k\sqrt{n}$, where e is closing error in minutes n number of Angles

	K.
1	1.39
2	2.22
3	1.50
4	0.58
5	1.51
6	4.24
7	1.38
8	2.00
9	1.70
10	1.55
11	0.38
Average	1.68

Error of Plotting

Ref. No.	Scale 1" =	Perim.	Closing Error Inches
1	40'	2208	0.03
2	20'	1546	0.01
3	100'	-	0.02
4	100'	-	0.05
5	100'	-	0.03
6	100'	-	0.05
7	50'	1625	0.016
8	40'	-	0.02
9	100'	-	0.02
		Average	0.027

Error of Calculating Area of Quadrilateral By Scaling Base and Altitude of Triangles.

Ref. No.	Error
1	0.0010
2	0.0050
3	0.0004
Average	0.0021

or $\frac{2}{10}$ of 1 per cent or $\frac{1}{5}$ of 1% or 1 in 500

Error from Map being out of scale.

1.8%

Also in area of 215 sq. in. error or difference of 2 plottings and calculations one part in 2857 or $\frac{1}{30}$ of 1 percent.

MISCELLANEOUS ERROR
Error of Plotting Lots

Scale 1" = 40'

Assuming Field Notes to be Correct

1st Check		3.0 Ft on Ground
2nd	"	1.0 " " "
3rd	"	0.5 " " "
4th	"	0.5 " " "
5 "	"	0.6 " " "
6 "	"	1.0 " " "
7 "	"	1.7 " " "
8 "	"	1.0 " " "
9 "	"	0.0 " " "
10 "	"	0.0 " " "
11 "	"	1.5 " " "
	Average	0.98 " "

Equal to 0.0245 inch on Map.

Miscellaneous Error

Error in Calculating Area by Division into Triangles

Scaling Base and Altitude and Multiplying.

	Area 1st Trial	Area 2nd Trial	Diff of Area	Per cent Difference
1st Triangle	80 908 Sq ft.	80 550	358	0.44
2nd "	109 490	109 777	287	0.26
3rd "	94 498	94 608	110	0.12
4th "	211 896	211 460	436	0.20
5 " "	126 004	125 568	436	0.35
6 " "	67 462	67 083	379	0.56
Scale 1" = 50'			6	1.93
(Average error $\frac{1}{3}$ of 1%)				0.32

Difference in area by Latitudes and Departures and by Triangles

By L. & D.	932360
" Triangles	943427
or 1.2%	11067

Error in Calculating Area By Latitudes and Departures

Difference in original and check Calculation

First Case 5 parts in one million
Second " 30 " " " "
Average 17 " " " "

MISCELLANEOUS ERROR

Difference in Level at Foot of Trees as Located From two Instrument Points by Stadia

First Case Av. of 16 0.9 Ft. *
Second " " " 13 0.4 "
* Trees on Hillside.

Error Planimeter

	Ared by Planimeter Sq.In.	Area by Ordinates	Diff.'	Per cent Diff.'
A.	8.46	8.30	0.16	2.0
B.	8.46	8.66	0.20	2.5
			2	4.5
				2.25

Average error $2\frac{1}{4}$ %

Error of Planimeter

	Area 1st Trial Sq.in	Area 2nd. Sq.In.	Diff.' Sq.in.	Per cent Diff.'
A.	124.77	124.43	0.34	0.27
B.	151.94	152.02	0.08	0.05
			2	0.32
				0.16

Average error $\frac{1}{6}$ of 1%

MISCELLANEOUS

Error in Stadia Difference of Level

Backsight and Foresight on Traverse.

1st Line	0.1 Ft.	27th Line	0.3
2nd "	0.0	28th "	0.1
3rd "	0.0	29th "	0.2
4th "	0.0	30th "	0.1
5th "	0.0	31st "	0.2
6th "	0.1	32nd "	0.1
7th "	0.0	33rd "	0.3
8th "	1.1	34th "	0.0
9th "	0.2	35th "	0.0
10th "	0.6	36th "	0.1
11th "	0.0	37th "	0.1
12th "	1.9	38th "	0.0
13th "	3.1	39th "	0.0
14th "	0.0	40th "	0.2
15th "	0.0	41st "	0.2
16th "	0.2	42nd "	0.2
17th "	0.1	43rd "	0.1
18th "	0.2	44th "	0.0
19th "	0.1	45th "	0.1
20th "	0.1	46th "	0.0
21st "	0.1		
22nd "	0.1		
23rd "	0.1		
24th "	0.0		
25th "	0.0		
26th "	0.0		

$46\overline{)10.4}$

Average 0.23

Including 8th, 12th, & 13th,

MISCELLANEOUS
Error in Chaining

Line	First Measurement	Second Meas.	Difference
A	145.0	144.8	0.2
B	305.0	304.95	0.05
C	204.7	204.6	0.1
D	150.0	150.5	0.5
	804.7	804.85	
		804.70	
		0.15	

$\frac{804.7}{0.15}$ = 1 part in 5365

Line	First Measurement	Second Meas.	Difference
E	1676.1	1676.2	0.1
F	1673.9	1674.2	0.3
G	1663.9	1663.8	0.1
H	1664.2	1664.4	0.2
	6678.1	6678.6	
		6678.1	
		0.5	

$\frac{6678.1}{0.5}$ = 1 part in 13,356

Line	First	Second	Differ.
I	372.3	371.9	0.4
J	219.3	219.0	0.3
	591.6	590.9	
	591.6		
	0.7		

$\frac{591.6}{0.7}$ = 1 pt. in 845

	One Part in
1st set	5365
2nd "	13356
3rd "	845

Average 6522 = 0.81 ft. per mile.

MISCELLANEOUS

Stadia

Time Required per 100 shots

Hours

	A	B	C
Field work	2.857	6.514	9.000

Office Work

Reduction by Diagram	0.645	0.651
Subtract for Elevation	0.266	0.488
Plotting after reduction	1.667	8.650
Total Office work	2.578	9.789
		10.800

Stadia

Time required per Acre

	A	B	C	Average
Shots per Acre	3.44	3.46	8.12	5.00
Field work	0.556	0.225	0.730	0.504
Office "	0.120	0.338	0.877	0.445
Total	0.676	0.563	1.607	0.949

Cost of Stadia Surveys per Acre

at $1.00 per hour for field work
and 0.50 " " " office

	A.	B.	C.	Average
Field	0.55	0.22	0.73	0.50
Office	0.06	0.11*	0.44	0.25
	0.61	0.34	1.17	0.75

Cost Stadia Surveys

Minimum 35¢ Average 75¢
Maximum $1.15 per Acre.

*At 30 cts. per hour.

Plotting Railroad Profile in Pencil.

Time	Miles
1 hr. 0 min.	3.50
1 " 0 "	5.25
0 " 34 "	4.25
1 " 0 "	3.00
0 " 30 "	3.00
4 " 04 "	19.00

4.67 Miles per Hour.

At 50¢ per hr.
Cost per Mile $0.11

Inking in surface line on profile
31½ miles per hour (10½ mls. in 20 min.)
Putting Sta. nos. on Profile also Elev.
figures on heavy lines 34 mls. per hr. (17 mls 30 min)

Making Railroad Profile

	Hours per Mile
Plotting in Pencil $\frac{1}{4.67}$	0.214
Inking in Surface Line $\frac{1}{31.5}$	0.032
Sta. Nos. and Elev. $\frac{1}{34}$	0.029
Lost Time $\frac{1.32}{17}$	0.078
Putting on Grade Line (Pencil)	0.161
Lost Time	0.067
Total Complete	0.570

At 50¢ per hr. Cost per mile $0.28

or 1¾ miles per hour Complete

MACHINE DESIGN

A Special Machine 74 Hours
20 Days including Sundays.

B Design for Gas Engine 118 Hours
90 days from start to finish
Including all lost time, correspondence etc. Sundays etc.

C Special Machine 45 Hours
21 days from beginning to completion

	Machine itself cost	Drafting Cost at 50¢ hr.	Per cent
Job A	$122.00	$37.00	30±
" B	500.00?	59.00	12±
" C	—	22.50	—

Machine Design Job B
Detailing Parts

No Pieces		Hours
1	Valve Box	4
1	By Pass	1
1	Gland	½
1	Crosshead	1
1	Connecting Rod	2
3	Small Pieces	7
4	" "	3
1	Lower Crank Case	3
1	Upper " "	3
14		24½

Average 1¾ hours per piece.
at 60cts. per hour cost $1.05 per piece.

MISCELLANEOUS

Ten Days Record on moving Earth

Ordinary slat bottom wagons

Cu. Yds. Moved Daily

Date	Cu. Yds.	Total	No Wagons	Place
4-24-12	86	86	2	Bowling St.
4-25-12	121	207	2½	" "
4-30-12	124	331		" "
5-1-12	141	472		" "
5-2-12	153	625		" "
5-3-12	157	782		" "
5-4-12	57	849		" "
5-6-12	95 Rain	944	3	" "
5-7-12	139	1083	3	" "
5-9-12	162	1245	4	" "

$10\overline{)1245}$ $\quad$ $5\overline{)14.5}$

125 $\quad$ 2.9

$\frac{125}{2.9}$ = 43 cu. yds. per day each wagon. Length of haul not noted.

Calculating Vertical Curves

Ref. No.	No of Curves	Minutes	Minutes to figure Vertical Curve.
1	1	4	4
2	1	20	20
3	1	25	25
4	6	95	16
5	1	35	35
6	1	18	18
7	2	70	35
8	1	60 (in field)	60
9	1	21	21
10	1	26	26
11	1	22	22
12	1	17	17
13	1	15	15
	19	428	22 Aver.

At 60 ft per Hour 22 ft each V.C.

MISCELLANEOUS

Farm Survey 337 Acres (Transit)

1st Day 610' per hr. Av. 6 hrs.
2nd " 8-30, 12-30 1521' " " " 4 "
2 " " 1-10, 3-10 1154' " " " 2 "
2 " " 3-10, 5-50 2392' " " " 2⅔ "
1257 Average 14⅔

3rd Day 9; 10-45 A.M. 1710' per hr. 1¾
" " 3701' Chained 10-45, 12-55, 1713 per hr. 2⅙
" " 5010' " 1-55, 3-55, 2505 " " 2
8711 20 7/12

4th Day

		Ft per Hr.	
11 a.m. 12 m.	1700'	1700'	1 hr
12, 12-40	891'	1337'	0 " 40 min.
1-10, 2-10	1200'	1200'	1 " 00 "
2-10, 3:00	2067	2480	0 " 50 "
	5858	1674	3 " 30 "
	8711	—	4 " 10 "
	14569	1900	7 " 40 "

Total time to run line 16 hr. 25 min.
" " " Rechain 7 " 40 "
Total for Job 24 hr. 05 min.
Cost at $1.00 per hour $24.08 net time
Length of Boundry 18036 = 3.48 miles
Cost per mile 24.08 ÷ 3.48 = $6.90 net time
Cost per Acre 7¢ on net time

Actual Cost 4 days @ $12.50 = $50.00
" " per Acre = 15 cts.
" " " Mile = $14.37

Mine Survey

Date	From	To	Hrs: Min.	Ft.	Ft. per hr.
11-11-08	8:09	11:45	3:36	1803	500
"	1:05	3:10	2:05	1473	707
"	3:10	5:00	1:50	669	365
			7:30	3945	526
	Lost Time		0:30	-	-
			8:00	3945	493
11-12-08	9:00	11:30	2:30	1156	462
"	1:30	4:30	3:00	1017	339
			5:30	2173	395
" Lost Time	8:00	9:00	1:00	0	0
" "	11:30	12:00	0:30	0	0
" "	1:00	1:30	0:30	0	0
" "	4:30	5:00	0:30	0	0
			8:00	2173	272
11-13-08	9:00	12:00	3:00	1913	656
"	1:40	3:40	2:00	1176	588
"	3:40	4:30	0.50	481	577
			5:50	3570	612
" Lost Time	8:00	9:00	1:00	0	0
" "	1:00	1:40	0:40	0	0
" "	4:30	5:00	0:30	0	0
			8:00	3570	446
11-14-08	9:00	10:30	1:30	915	610
"	10:30	12:00	1:30	980	654
"	1:50	4:15	2:25	1670	691
			5:25	3565	657
" Lost Time	8:00	9:00	1:00	0	0
" "	1:00	1:50	0:50	0	0
" "	4:15	5:00	0:45	0	0
			8:00	3565	445

Mine Survey

Date	From	To.	Hrs. Min.	Ft.	Ft. per hr.
11-16-08	10:30	12:00	1:30	871	581
"	1:25	4:00	2:35	1466	570
			4:05	2337	572
" Lost Time	8:00	10:30	2:30*	0	0
" "	1:00	1:25	0:25	0	0
" "	4:00	5:00	1:00	0	0
			8:00	2337	292

*Tape burnt in two.

Summary

Date	Time actually worked	Total Time	Ft.	Ft. Per Hour Rate on total time	Rate on net time
11-11-08	7:30	8:00	3945	493	526
11-12-08	5:30	8:00	2173	272	395
11-13-08	5:50	8:00	3570	446	614
11-14-08	5:25	8:00	3565	445	658
11-16-08	4:05	8:00	2337	292	571
	28.20	40.00	15590	390	550

Error in Chaining on Farm Survey

(See P. 32)

Ref. No	Original Measurement	Remeasured	Difference	One part in
1	192.0	189.5	2.5	76
2	175.0	166.9	8.1	20
3	216.0	208.4	7.6	27
4	108.0	104.0	4.0	26
5	145.0	137.8	7.2	19
6	310.0	293.0	17.0	17
7	120.0	117.6	2.4	49
8	109.0	108.7	0.3	363
9	374.0	359.2	14.8	24
10	106.0	106.0	00.0	—
11	278.0	264.7	13.3	20
12	859.0	858.8	0.2	4295
13	215.0	214.5	0.5	429
14	155.0	153.8	1.2	128
15	256.0	252.8	3.2	72
16	348.0	317.8	30.2	10
17	245.0	227.5	17.5	13
18	201.0	195.7	5.3	37
19	72.0	70.5	1.5	47
20	51.0	51.0	0.0	0.0
21	367.0	335.7	31.3	11
22	133.0	114.0	19.0	6
23	365.0	300.0	65.0	5
24	183.0	166.0	17.0	8
25	344.0	302.3	41.7	8
26	120.0	92.9	27.1	4
27	220.0	218.0	2.0	109
	6267.0	5927.1	339.9	18

* Dentist and College Student as Chainmen. Tape not kept level.

MISCELLANEOUS

Mine Survey (Underground)

Ref. No.	Date	Hrs.	Ft.	No. Helpers	Ft. per Hr.
1	1902	–	–	7	900
2	1902	–	–	4(?)	800
3	1904 (Phosphate)			–	300*
4	1905	7	3150	–	450
5	1906	8	2200	–	275
6	1906	2½	1000	–	400
7	1907	7	1840	–	263
8	1907	5	2860	–	572
9	1908	1½	380	–	253
10	1908	5	1416	–	283
11	1908	4 11/12	1617 (Angles Doubled)		329
12	1910	1¾	1440		825
13	1912	6	–	3	358
14	1908	8	3945	2	*493
15	1908	8	2173	–	*272
16	1908	8	3570	–	*446
17	1908	8	3564	–	*445
18	1908	8	2337	–	*292

(Average of Nos. 13 to 18 incl. = 389) 468 = Aver.*

*On basis of total time including lost time.

Estimate of Cost per Mile.

	Per hour
Engineer	$1.00
3 helpers @ 25¢	0.75
	$1.75

$\frac{5280}{468}$ 1.75 = $19.75 per mile.

CONDENSED COSTS

Ref. No.			
1	Chaining (P.1) average	$1.60	mile
2	Compas (P.1) "	3.20	"
3	Transit Line Open Fields (P.1)	5.70	"
4	" " Woods (P.2)	10.80	"
5	Leveling (100' stas) (P.3)	2.40	"
6	" with shots 20' Rt. + L. (P.3)	5.25	"
7	Cross Sectioning Roads (P.4)	8.65	"
	Stadia		
8	Delays deducted (P.5)	$2.42	per 100 shots
9	Lost time included (P.6)	4.55	" 100 "
	Road Survey by Stadia and		
10	Magnetic Needle (P.7)	$ 0.66	mile
11	"Mill Pond" stadia work	6.05	"
	Grade Stakes		
12	"Line and Grade" (P.8)	$30.00	mile
13	Survey of a town (P.8)		
	Average of 5	$172.00	for Complete Survey
14	Town Surveys (P.8)		
	per mile of Street av.' of 4	$23.00	
15	Topographic Survey of a Tract		
	by division into 100' squares and		
	taking levels at corners (P.9)	$1.73	per Acre
16	Lay off City Building Lots (P.10) Field wk.	$0.44	per Lot
17	" " " " "Curved Frount	1.14	" "
18	Stadia Surveys (P.11)		
	Average at $15.00 per day for party	$0.90	per Acre
19	Layout Driveways to Residence (P.11)		
	(Short Radius Curves) net time	$1.00	per 100'
20	including lost "	1.50	" 100'
21	Railroad Surveys (P.11) Preliminary	$25	per mi.
22	Location	$75	" "
23	Railroad Curves (P.12) (curves only)	$16	" "
24	" Cross Sectioning (P.4)	$12.20	" "

CONDENSED COSTS

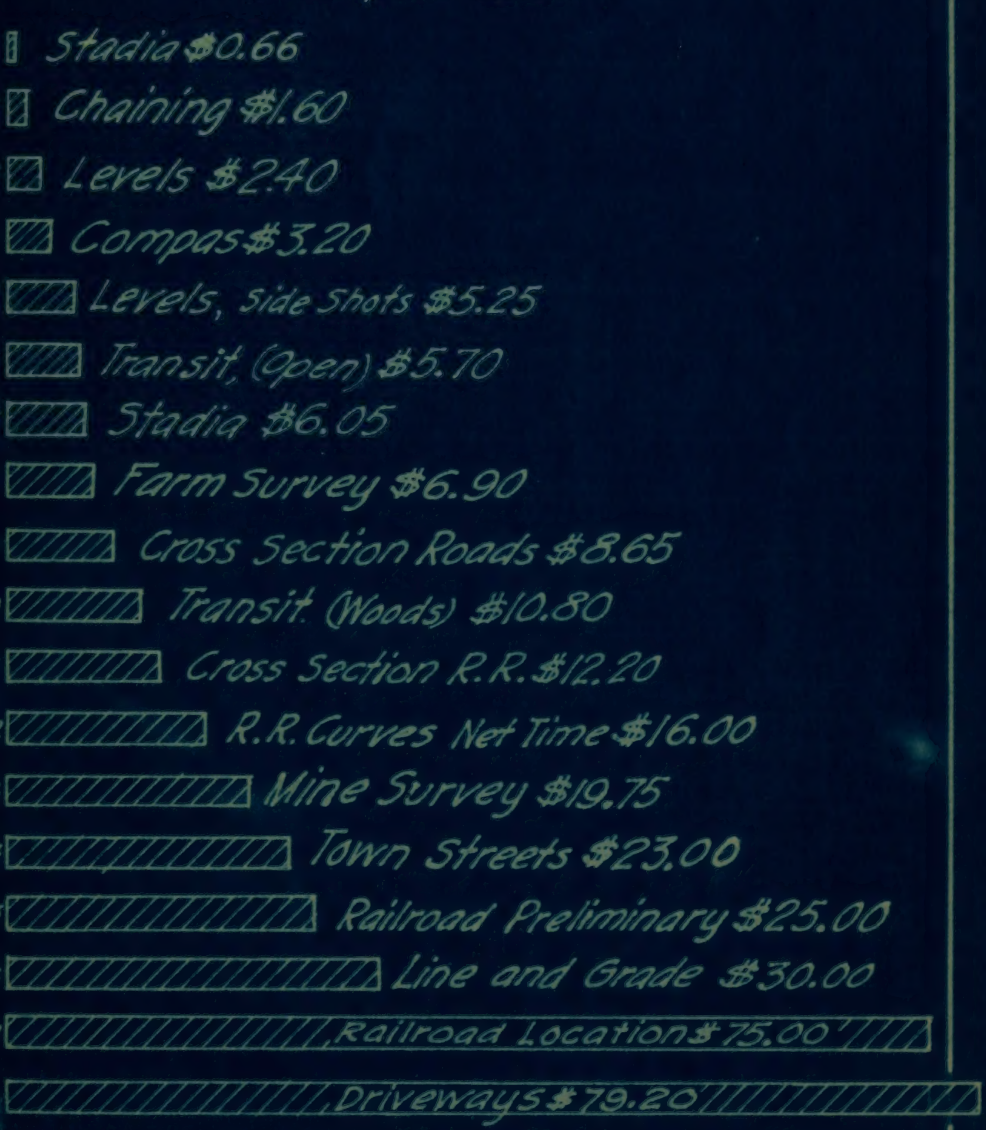
Office Work

Drafting (tracing) (P.13) @ 50¢ hr. $0.95 per sq. ft.
Calc. Lat. & Deps. (P.14) minutes $3.15 per 100 courses
" " " " (P.14) ¼ deg. 1.25 " 100 "
Calculating Cross Sections Roads (P.15)
and Checking with Planimeter $29.50 per 100 sec.
without " " " 11.65 " 100 "
Calc. R.R. Cross Sections (P.15) 5.00 " 100 "
Big R.R. Cut (P.16) 15.00 " 100 "
Areas by Planimeter (P.17) 20.00 " 100 "
" " Paper Strip (P.17) 1.95 " 100 "
Calc. area Farm (P.18) $1.15 per 100 Acres
Plot Traverse (P.18) 1.30 " 100 Courses
" Lots (P.19) 2.55 " 100 Lots
Lay off city lots complete (P.19) 46½¢ per Lot
Reduce Stadia Notes (P.20) $0.30 per 100 shots
Plot " " (P.20) net time 0.90 " 100 "
" Stadia Notes (including lost time) $1.05 per 100 "
Stadia Surveys (P.28) average $0.75 per Acre
Plot R.R. Profile (P.29) 0.28 " mile
Machine Design (P.30) $39.50 for 1 machine
Vertical Curve (P.31) 22 cts. each.

Field Work

Farm Survey $0.07 per Acre (P.32)
" " per mile of boundry $6.90 (P.32)
Mine Survey (P.36) $19.75 per mile.

Cost per Mile.


1 Stadia $0.66
2 Chaining $1.60
3 Levels $2.40
4 Compas $3.20
5 Levels, Side Shots $5.25
6 Transit, (Open) $5.70
7 Stadia $6.05
8 Farm Survey $6.90
9 Cross Section Roads $8.65
10 Transit (Woods) $10.80
11 Cross Section R.R. $12.20
12 R.R. Curves Net Time $16.00
13 Mine Survey $19.75
14 Town Streets $23.00
15 Railroad Preliminary $25.00
16 Line and Grade $30.00
17 Railroad Location $75.00
18 Driveways $79.20

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